Motor Vehicle Lamp Examination and Analysis

1. Scope

The purpose of a motor vehicle lamp examination is to determine the on/off condition of lamp evidence. Lamp evidence is defined as any headlamp, tail lamp, indicator lamp (turn signal, emergency lamp), instrument panel lamp, or marker lamp that may be recovered from a vehicle involved in an accident. The primary purpose of a lamp examination is to determine whether the lamp was lighted (on) or unlighted (off) at the moment of impact during normal operation of the vehicle, or in an accident.

The stresses generated on a filament by the accelerations and sudden stops of a collision produce deformation and fracture phenomena, with characteristic differences observed between hot and cold filaments. Additional information may be obtained if the glass bulb is broken during the accident. If the filament is hot, it will be oxidized and it may melt any broken glass that comes in contact with it. These characteristics are observed and documented in order to form an opinion as to the on or off condition of the filament(s) at the time of an impact.

Although lamp examinations are most commonly conducted on motor vehicle lamps, lamp examinations can also be conducted on other types of vehicles and objects. Any lamp having a tungsten filament may be examined, including boats, motorcycles, farm equipment, caution signs, and traffic lights. Fluorescent and LED lamps are not amenable to this examination.

2. Terms and Definitions

Glass envelope - the glass bulb or globe that encloses the filament in an environment from which air has been removed, and an inert gas (nitrogen, iodine, etc.) has been introduced.

Filament - a uniform coil of tungsten wire place between two supports. When the lamp is energized, electricity will flow through the filament and heat it. When the temperature reaches 4000 °F, the filament will glow (become incandescent) and produce light.

Filament support - steel supports which suspend the filament in the glass envelope.

Base - the shell, pin, insulator and contact portion of a lamp which fits into a plug or receptacle.

Lugs - metal tabs on the back of the glass envelope of a headlamp. Lugs fit into the plug and make electrical contact.

Normal lamp - after an accident, a normal lamp shows no signs of being lighted or unlighted at the time of the impact. Therefore, no opinion can be given concerning the on or off condition of a normal lamp.

Sealed beam lamp - a glass lens and reflector form a sealed glass envelope to provide an air-free environment for the filament and proper reflection for the light.

Halogen lamp - a glass lens and reflector which also contains a smaller, inner bulb. This bulb contains a halogen gas (usually iodine) and burns brighter, lasts longer, and uses half the power.

Incandescent - as electric current flows through a filament, the resistance of the filament metal causes the production of heat. When the temperature reaches 4000 °F, the filament glows with white heat, producing light.

Trade number - this is the most common marking found on the base of lamps. It represents the size, shape, filament configuration, wattage, voltage, contact arrangement, etc. of the lamp.

Age sag - this occurs in long, thin filaments and is a uniform, gradual downward drooping with age in the filament.

Burnout - occurs as tungsten leaves the filament by evaporation. This causes a gradual pitting and thinning of the filament. As resistance increases in these thinner areas, hot spots occur. This continuous increase in evaporation and temperature proceeds until the temperature reaches the melting point of tungsten. The filament burns out at this point. Bulbous, teardrop-like ends, or drawn out ends at the point of separation are characteristic of burnouts.

Cold fracture - brittle fractures occur with vibration or impact in a cold (off) filament. Impact occurs when the lamp is not energized, no stretching or thinning of the filament occurs, and there is no melting. The filament snaps in two, leaving squared-off ends and/or sharp projections.

Oxidation - occurs in lamp filaments when air is allowed to reach an incandescent filament due to glass envelope breakage.

Blackened filament - a blackened filament is characteristic of a filament that was energized (on) after the glass envelope was broken.

Bright filament - a shiny, bright filament is characteristic of the filament being cold (off) when the glass envelope was broken.

Tinted (rainbowed) filament - rainbowing is usually found in two filament lamps, where one filament was on and the other off (but warm, due to its proximity to the energized filament) when the glass envelope was broken. The incandescent filament will be more heavily blackened.

Hot shock - an incandescent filament is ductile, and will stretch out, uncoil or tangle from the force of an impact, either without breaking, or before breaking.

Fused glass - when glass particles from the broken glass envelope come in contact with an incandescent filament, they melt and are fused to the filament or filament supports.

3. References

Baker, Fricke. Baker, Aycock, Lamp Examination for On or Off in Vehicle Collisions, Northwestern University Traffic Institute,

Coldwell, Melski, “Motor Vehicle Lights as Evidence in Traffic Accident Investigations”, RCMP Gazette, May 1961, pgs. 2-8.

Dolan, D.N., “Vehicle Lights and Their Use as Evidence”, Journal of Forensic Science Society, 1971, Vol. II, No. 2.

4. Examination Procedures

4.1. Limitations

Some lamps, such as fluorescent and LED lamps, do not have filaments, and therefore cannot be examined for on/off condition at the time of an impact. If the damaged area is too far from the lamp in question, the filament may not have sustained sufficient impact force to effect changes in the filament. If there is no damage to the lamp or filament, no meaningful determinations can be made. Lamp filaments are fragile and may be too damaged to make a determination.

4.2. Chemical and Procedural Precautions

Refer to the TBI Safety Manual for general safety requirements and hazard information regarding the use of reagents and solvents, and overall safety guidelines.

Use caution when examining lamps. Broken bulbs may have sharp edges and can produce severe cuts. Small glass shards can also be propelled from the lamp or packaging. When working with broken lamps, eye protection should be considered. When opening the glass envelopes of lamps, eye protection should be worn.

Use caution when testing circuits. Electrical circuits may be energized and could produce electrical shocks.

Never look directly into a lighted lamp with the naked eye. The intense light emitted by a lighted lamp can cause injuries to the eyes.

4.3. Instruments and Equipment

Stereomicroscope
Video microscope (Keyence)
Voltage meter

4.4. Procedure

Document submitted samples according to *Microanalysis Quality Assurance Policy*.

Document any and all packaging of the submitted evidence lamp. Innermost packaging should be opened over catch paper in order to retain any small items or loose portions of the lamp. The evidence and packaging should be examined to determine if any damage could have occurred in handling. Note and record any inappropriate or inadequate packaging.

Thoroughly document the lamp in its original condition. Note and record the description and condition of the lamp. Photographs should be made in this original condition.

Documentation of the lamp may include the brand, type, base arrangement, electrical rating (voltage/wattage), and purpose in the vehicle, if known.

Utilizing a Lamp Examination Worksheet may assist the forensic scientist in documenting the physical and microscopic characteristics of the lamp or lamp portions. In some cases, the glass envelope may need to be removed for complete examination. If the glass envelope needs to be removed, the lamp should be photographed before and after removal. See *Opening the Glass*

Envelope below.

4.4.1. Physical Characteristics to Observe during Lamp Examinations

4.4.1.1. Condition of the glass envelope:

Is it intact?
Is it loose from the base?
Is it fractured or cracked?
Is it missing? If so, what percent (estimate)?
Is there any darkening resulting from the aging process and tungsten evaporation?
Are there any yellow or white tungsten oxide deposits? These deposits indicate exposure to air while the filament was incandescent.

4.4.1.2. Condition of the base and lugs:

Are they intact?
Are they damaged? If so, describe the damage.
Are they missing?
Is there any corrosion present?

4.4.1.3. Condition of the filament supports:

Are they bent?
Are there whitish deposits? Be aware of the difference between "doping" and tungsten oxide deposits.
Are they missing? The mechanical action of a moving filament support can break a cold filament or uncoil a hot filament.

4.4.1.4. Condition of the filaments, to include symmetry and spacing of the coils, and continuity of the filament.

4.4.1.4.1. Document the symmetry and spacing of the coils:

Normal coils can be determined by a comparison to a new bulb (reference standard) of the same part number and manufacture. Undamaged filaments will have shiny coils which are uniformly spaced, with no arching or kinking of the filament (or very little). Manufacturing irregularities may produce a curve in a normally straight filament. These irregularities can be mistaken for mild hot shock. Use caution when considering a mild hot shock conclusion because of this.

Age sag effects are seen in small filaments used over a long period of time. Therefore, the sagging will be in a downward orientation, and will usually be accompanied by glass darkening that occurs in the aging process. This enforces the need to mark lamps at the scene as to their orientation in the vehicle (up/down). Age sag is rarely seen in headlamp filaments due to their relatively large diameter.

Mild hot shock will show noticeable irregularities in coil spacing (as compared to unused new lamps). These irregularities will exceed those normally seen in unused new lamps.

Hot shock will show noticeable stretching, uncoiling, or tangling of the filament, with or without breaking.

4.4.1.4.2. Document the continuity of the filament visually and with a voltage meter.

An intact filament indicates the filament did not sustain a sufficient impact to cause separation. A voltage meter may be used to determine if the filament is operational.

A broken filament may result from:

Burnout

Burnout is not related to impact, and is a result of normal use over time. In burnout, broken filament ends will be tapered and drawn out, or bulbous as a result of the melting of the tungsten filament.

Hot shock separation

Hot shock separation is a result of an impact near the lamp while the filament was warm or incandescent. In the case of hot shock separation, the filament will be elongated or stretched, and may show signs of “whipping”. Filament ends may appear tapered and drawn out, similar to those of a burnout, but will not show the bulbous characteristics of burnout.

Cold fracture

Cold fracture is a result of an impact near the lamp while the filament was cold/off. In the case of a cold fracture, the filament will show no signs of elongation, and may be fractured in more than one location. The filament ends will appear jagged or squared off. Cold fracture can occur at any time with a cold filament:

A filament that is burned out prior to an impact is particularly susceptible to cold fracture from any subsequent impacts, as one end of the filament is unattached at the point of burnout. The fracture can occur in multiple areas, and multiple filament fragments may be loose in the glass envelope.

A filament that was warm/incandescent at the time of an accident may also stretch/uncoil and separate due to the forces of impact. This broken filament will cool rapidly. Any subsequent impact can then produce a cold fracture in this filament, also producing multiple filament fragments in the glass envelope.

A filament that was warm/incandescent at the time of an accident may be broken during transport to the laboratory, producing multiple filament fragments in the glass envelope.

In each of the above situations, examine all of the fragments in the glass envelope to determine the original condition of the lamp filament. If the filament was burned out prior to impact, there will be a bulbous or tapered/drawn out end present on one of the fragments. If the filament was warm/incandescent, fragments of the filament will exhibit characteristic stretching/uncoiling, etc.

4.4.1.5. Document the appearance of the filament:

Shiny filament
The filament may be intact or broken, but rarely deformed. This is especially important if glass envelope is broken, indicating that the filament was cold/off at the time of the impact.

Tinted filament (also called rainbowing)
Tinted filaments result from oxidation which occurred when the glass envelope was broken while the filament was warm (soon off or adjacent to an incandescent filament). The tinted filament may be intact or broken, and may or may not be deformed.

Blackened filament
A blackened filament is heavily oxidized, and indicates that the

filament was hot and on when the glass envelope was broken. A blackened filament may be intact or broken, and may or may not be deformed.

4.4.1.6. Document the presence or absence of fused glass particles on filaments if the glass envelope is broken. The presence of fused glass is an indication that the filament was on when the glass envelope was broken. The absence of fused glass is not an indication that the filament was off when the glass envelope was broken.

4.4.2. Microscopic Examination

4.4.2.1. Symmetry of Filament Coils
Microscopically compare the evidence filament to unused new lamps of same manufacturer and part number.

4.4.2.2. Intact or Separated Filaments
Microscopically examine the filament for:

Burnout, including bulbous or tapered ends.

Hot shock, including bulbous or tapered ends with stretching and/or uncoiling.

Cold fracture, including jagged or squared ends.

4.4.2.3. Shiny, Tinted, or Blackened Filaments

Little information can be gained by examining tinted or blackened filaments microscopically.

Shiny filament
With a shiny filament, draw lines or extrusion marks in the filament may be observed microscopically, and may indicate a new filament with little use.

Pitting on the filament surface may be visible microscopically, and indicates an older filament. Pitting is caused by evaporation of tungsten during incandescence. A pitted filament that is slightly bowed may appear to be mild hot shock. Pitting and bowing together are good indicators of the age of the filament, and the bow may be age sag, rather than mild hot shock.

4.4.2.4. Presence or Absence of Fused Glass Particles
Microscopic examination may be necessary to detect small fused glass particles.

Small glass particles may be melted onto the filament.
Larger particles may melt onto the filament supports
Dust and debris may appear to be fused glass. A small probe can help determine whether the item is actually fused to the filament or support.

4.4.3. Opening the Glass Envelope

Any attempt to open the glass envelope of lamps should be made only after careful examination of the filaments through the glass. A voltage meter should be used for continuity testing prior to opening the glass envelope. Opening the glass envelope will produce shards of glass, and should be done with strict attention to the safety of the forensic scientist and nearby personnel. Eye protection should be worn.

Be sure to accurately note the condition of the filament(s) before attempting to open the glass envelope. Documentation may be in the form of sketches and/or photography.

4.4.3.1. Taillight/Indicator Lamps

Completely tape over the glass surface. This permits controlled breaking of the glass envelope.

Wearing protective eyewear, place the glass portion of the lamp between the jaws of a vise, and slowly close the jaws until the glass envelope cracks.

Remove tape and glass sufficient to expose the filament(s).

Collect any loose filament portions or glass in a petri dish or other suitable container.

Examine the filament(s) and glass as previously described.

4.4.3.2. Headlamps

No attempt should be made to open the glass envelope of the small bulbs in halogen lamps. The bulb itself is pressurized and will likely explode if the glass is cracked or etched in any significant way.

Relieve the pressure inside the glass envelope by opening or breaking the evacuation port between the lugs on the back of the lamp. The lamp should be covered with a towel to minimize any flying debris. Eye protection should be worn.

4.4.3.2.1. Vise Method for Opening Headlamps

Place the glass envelope in a clear plastic bag. This will retain pieces of the envelope after it is broken.

Wearing protective eyewear, and with the bag covered with a towel, place the glass envelope in the jaws of the vise and close them slowly until the glass fractures.

Collect any loose filament portions in the bag and in the lamp for a complete examination.

Examine the filament(s) and glass as previously described.

4.4.3.2.2. Heating Method for Opening Headlamps

Wearing protective eyewear, place the lamp lens down onto a heat resistant surface.

Using a propane torch or electric charcoal starter, heat the area on the back of the lamp around the lugs.

After the glass is very hot, lay a cold, wet towel across the heated area. The glass should crack. This heating/quick cooling process may have to be repeated until sufficient breaking occurs in order to remove the glass envelope from around the lugs. Extra care should be taken due to the extreme heat of the glass. Allow sufficient time for cooling before handling.

Examine the filament(s) and glass as previously described.

4.4.4. Evidence Repackaging

Lamp evidence should be repackaged to prevent any change or damage during storage, handling, or transport. This should include covering exposed filaments with a sturdy container taped in place, and preservation of any lamp portions which were important in the examination and forming of an opinion. Care should be taken that any broken glass does not pose a danger to subsequent handlers.

5. Reference Materials

Known lamp standards may be used for comparisons. These lamps may be purchased from any retail lamp distributor.

6. Reports

All interpretations of results to include lamp description, observations, and conclusions shall be recorded in the notes. Conclusions shall be based on the presence of, or the lack of, characteristics on each lamp or lamp portion. Lamp examinations require verification of each conclusion reached.

Techniques utilized in lamp examinations should be included in the official report. A description of the lamp and its purpose on the vehicle may be included in the exhibit description or in the examination results. The condition of the glass envelope may also be included in the exhibit description or in the examination results. Below are examples of the wording of results. The exact wording of the results will vary depending on condition of the lamp.

Normal Condition

The filament in Exhibit ___ was examined visually and microscopically, and found to be in normal operating condition. Therefore, no opinion could be formed as to the on or off condition of the filament at the time of an impact.

Cold – Off at Time of Impact

Visual and microscopic examination of the filament in Exhibit ___ revealed the presence of cold fracture characteristics sufficient to conclude that the filament was off at the time of an impact.

Hot – On at Time of Impact

Visual and microscopic examination of the filament in Exhibit ___ revealed the presence of hot shock characteristics sufficient to conclude that the filament was on at the time of an impact.

Inconclusive

Visual and microscopic examination of the filament in Exhibit ___ failed to reveal distortion characteristics to indicate the on or off condition of the filament at the time of an impact.